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Preliminary Ceramic Compositional Analysis from the La Arenera Site, Pacific Nicaragua

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ABSTRACT

Ceramic compositional analysis has begun to provide critical support in understanding ceramic economy, especially production and distribution strategies, and archaeological typology in Pacific Nicaragua that was previously based primarily on surface decoration. Here we present preliminary results of an ongoing study exploring the paste composition of Tempisque period (500B.C.–A.D. 250) Izalco-style Usulutan and Rosales Zoned Engraved ceramic types from the site of La Arenera. Findings suggest that Rosales wares were produced within Pacific Nicaragua but, based on petrological composition, were likely produced beyond the site itself. Further, all Usulutan-like samples were likely produced within Pacific Nicaragua—a contradiction to our original hypothesis that some of the Usulutan-like wares were imports from El Salvador and others locally made. Of particular interest is the presence of two discrete compositional paste types for the Nicaraguan-produced Usulutan-like wares which indicate distinct and unrelated parent rock (and thus geological and geographical) sources for the clays and inclusions. In the final discussion we explore what the results of this preliminary analysis may intimate about the local ceramic economy of La Arenera and its broader external social connections.

INTRODUCTION

When we began our preliminary research for this paper the goals were relatively modest; we wanted to—through a combination of quantitative and qualitative petrological compositional analyses—both create a description of and identify the relationship between what we believed were (1) imported Usulutan ceramics and, (2) locally-produced Usulutan imitation and Rosales Zoned Engraved types from the site of La Arenera, Managua, Nicaragua (Figure 1). Our preliminary results have, however, led to a unique and far more interesting glimpse into the ceramic economy of a Tempisque period (500B.C.–A.D. 250) occupation entombed by volcanic debris. What we found were distinct types of Usulutan, the majority of which appear to have been produced within Pacific Nicaragua, and non-local to the site, but still likely Nicaraguan-produced, Rosales Zoned Engraved wares. This provides a very different, though equally complex, picture of the local ceramic economy than initially expected.

Our presentation begins with a brief overview of the site itself, including the sample selected for presentation. This is followed by a more technical look at the method, results, and interpretation of the compositional analyses. In the final discussion we undertake a cursory overview of Usulutan ceramic production at an interregional level, situate our sample in relation to this data, and begin to formulate potential sociocultural interpretations for the trends we are seeing at La Arenera.

Figure 1. Location of Managua City, Nicaragua (from: news.bbc.co.uk).

LA ARENERA

Located at the base of the Nejapa-Miraflores volcanic alignment (a series of fissure vents) on the northwest side of modern day Managua City the site of La Arenera, which literally translates to "the sand quarry," covers an area ranging somewhere between 40 hectares and 1 km^2 (McCafferty 2009; McCafferty and Salgado 2000). A preliminary evaluation of the site conducted in 2000 led by Geoff McCafferty and Silvia Salgado Gonzalez identified a well-preserved Tempisque period—or La Colonia phase (500 B.C.–A.D. 300) in the local Managua chronology—occupation buried beneath layers of volcanic sand and/or debris (Figure 2). This temporal placement is identified by diagnostic Tempisque ceramic types including negative resist painted Usulutan-like wares, Rosales Zoned Engraved, and Obanda Black-on-Red. Also present in the excavations were obsidian materials—possibly from the Guinope source in Honduras. It may be that earlier occupations exist at La Arenera but the brevity of excavations in 2000 did not permit deeper stratigraphic exploration. Above the layers of volcanic sand is evidence of final reoccupation dating to approximately A.D. 1–300. However, ceramics discovered within the occupational level also include traces of diagnostic Bagaces period (A.D. 250–800) ceramics including Chavez White-on-Red (McCafferty and Salgado 2000) which may suggest a slightly longer and more recent extension of the occupational sequence.

Figure 2. The archaeological surface with volcanic sand layer in profile behind (McCafferty 2009).

The Ceramic Sample

Our sample selection focused on the Tempisque period occupation buried beneath the volcanic sands. These16 sherds were expressly selected by Platz, in consultation with Silvia Salgado of the University of Costa Rica, to help create a description of and identify the relationship between what we believed were a combination of imported Usulutan ceramics and locally-produced Usulutan-like “imitation” and Rosales Zoned Engraved types from the site (see Table 1). Because Usulutan-style ceramics have been characterized as a significant marker of the Mesoamerican southeast periphery and, in general, Mesoamerican influence for so many years (Cagnato 2008; Demarest and Sharer 1982; Goralski 2008), it was deemed prudent and most interesting to examine how the examples at La Arenera “fit into” current understandings of the broader pre-Columbian Usulutan ceramic sphere. Initially, we hoped to discover the production location from which the “real” Usulutan-like sherds originated. The Rosales Zoned Engraved type was selected for two reasons: first, because it is an ubiquitous and diagnostic Tempisque period type in Pacific Nicaragua specifically, and Greater Nicoya, generally (Healy 1980:211; Lange 1992:115); and second, because we assumed this type—based on macroscopic visual similarities in paste colour and texture—would be directly comparable to what we believed were locally-produced Usulutan “imitation” wares.

Table 1. Petrological Thin Section Samples from La Arenera.

Thin Section ID	Catalogue # (N-MA)	Type	Variety	Vessel Form	Comments
AR1	65-00-30-B-22	Usulutan	Red Rim	Dish (?)	Real?
AR2	65-00-37-B-16	Usulutan	Red Rim	Comp. Silhouette	Real?
AR3	65-00-36-B-7	Usulutan	Red Rim	Comp. Silhouette	Real?
AR4	65-00-31-B-10	Usulutan	Red Rim	Comp. Silhouette	Real?
AR5	65-00-30-B-180	Usulutan	Red Rim	Comp. Silhouette	Real?
AR6	65-00-30-B-33	Usulutan		Comp. Silhouette	Imitation
AR7	65-00-36-B-73	Usulutan		Collared Bowl	Imitation
AR8	65-00-31-B-85	Usulutan		Collared Bowl	Imitation
AR9	65-00-30-B-105	Usulutan		Dish (?)	Imitation
AR10	65-00-31-B-68/?	Usulutan		Shallow Bowl	Imitation
AR11	65-00-30-B-72	Usulutan		Comp. Silhouette	Imitation
AR12	65-00-30-B-656	Rosales Zoned Engraved		Large Bowl	
AR13	65-00-30-B-691	Rosales Zoned Engraved		Large Bowl	
AR14	65-00-30-B-639	Rosales Zoned Engraved		Comp. Silhouette	
AR15	65-00-30-B-644	Rosales Zoned Engraved		Large Bowl	
AR16	65-00-30-C-218	Rosales Zoned Engraved		Unknown	

The “real” Usulutan sherds (n=5; described as Usulutan Red Rimmed in the compositional analysis) were initially identified as Late to Terminal Preclassic (100 B.C.–A.D. 250) Izalco-style Usulutan wares based on their characteristic descriptive definition of a lighter-coloured, hard-fired fine paste with multiple wavy-lined resist decoration (see Figure 3) (Demarest and Sharer 1982:813, 819). Many of these sherds demonstrate a carbon-rich reduced core which seems to be characteristic of hard-fired fine paste ceramics from throughout El Salvador and Honduras.

Figure 3. An Izalco style Usulutan sherd from La Arenera (McCafferty 2009).

The “imitation” Usulutan wares (n=6), although displaying the diagnostic multiple wavy-lined resist decoration, were generally of a coarser, iron-stained (reddish coloured) paste. According to Dennett, to the naked eye these samples look generally more similar to typical pastes from Pacific Nicaragua across all chronological periods, and dissimilar to the Usulutan Red Rimmed samples. Paste colour and visible inclusions in the fabric make these “imitation” Usulutan sherds seem more closely related (though in no way identical) to the typical Rosales Zoned Engraved (n=5) fabrics from La Arenera.

CERAMIC COMPOSITIONAL ANALYSES

Traditional ceramic analyses in Pacific Nicaragua have focused on typological classification typically based on a combination of surface decoration and vessel form (e.g., Healy 1980; Knowlton 1996; Lothrop 1926; Norweb 1964; Salgado 1996; Steinbrenner 2010). Preliminary compositional analyses utilizing a combination of NAA and petrological methods, however, have given us more in-depth information regarding general geographical manufacture zones and, potential hints toward, distribution patterns (Bishop et al. 1988, 1992). Our ongoing research project is aimed toward using this same combination of archaeometric techniques in order to garner a better understanding of Tempisque period materials—a chronological time period that has never been studied utilizing these methods. While we anticipate equally interesting and informative results from the NAA analysis of our sample sherds (currently being conducted by Ron Bishop of the Smithsonian Institution), we are unable to report on this aspect at this time. Herein we report the petrological component of the analysis.

Methodology

The analyses utilized in this project involves a combination of well-established quantitative (point counting) and qualitative (examination of lithic and mineral inclusions utilizing optical microscopy) techniques for describing and interpreting the composition of archaeological ceramic fabrics. Quantitative analysis of the samples was completed by Platz and Dennett utilizing standard point counting procedures (Bishop et al. 1982; Stoltman 1989, 1991). This method involves the measurement and classification (lithic vs. mineral) of the grain size of inclusions in the paste using a 1 x 1 micrometer grid superimposed on the slide to obtain a random, representative sample. Grain inclusions less than 0.02 mm are categorized as matrix (inclusions presumed native to the clay), 0.02 to 0.55 mm as silt, 0.55 to 2 mm as sand, and anything larger is considered gravel. The results of point counting procedures should aid the ceramic analyst in potentially distinguishing unique "paste recipes" and constructing basic research questions which can then be addressed and/or clarified through qualitative petrological description. Qualitative analysis of the samples was completed by Dennett using standard petrological optical microscopy procedures designed to identify and describe the different types of mineral[1] and lithic inclusions present in the fabric (Bishop et al. 1982).

Results and Analysis

Quantitative Point Counting: Results

Figure 4 features a ternary diagram that visually outlines the results of our point counting procedure. Individual point count summaries are represented based on the proportions of

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[1] Different characteristics observed under polarized light to aid in the identification and description of mineral inclusions include aspects of pleochroism, extinction angle, relief and/or cleavage, and birefringence, among other optical properties.

matrix, silt, and sand sized inclusions present in each. Because the presence of gravel-sized inclusions was extremely rare (to the point of insignificance), this variable was eliminated from the procedural result quantification. Samples of initially presumed imported Red Rimmed Usulutan wares are represented with red squares, locally-produced “imitation” Usulutan in yellow, and Rosales Zoned Engraved in blue.

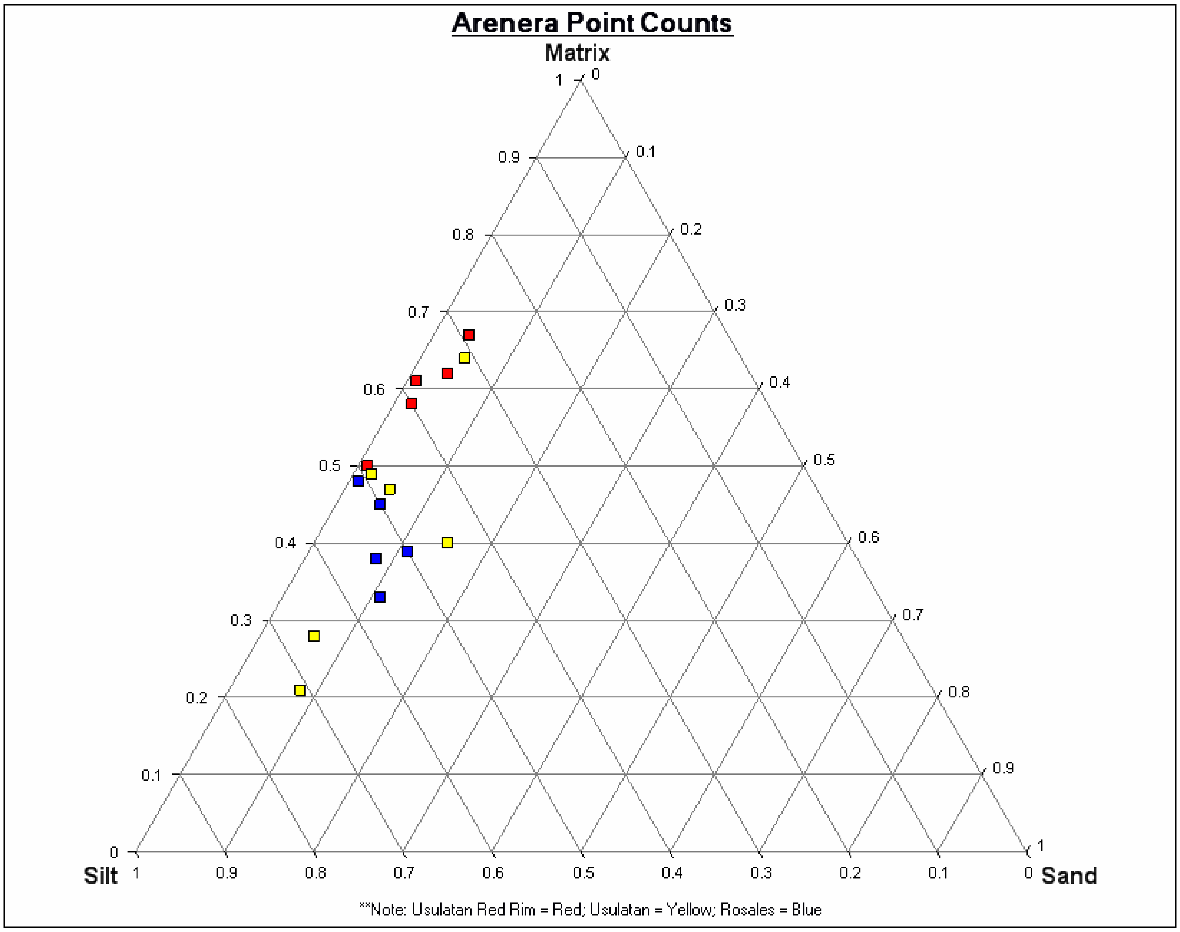

Figure 4. Inclusion grain-size proportions for individual sherds in the La Arenera sample.

Several distinct trends were observed in the proportional grain sizes of the three sample types. Red Rimmed Usulutan sherds cluster fairly well, based on grain size, and lean toward a more matrix-rich composition than either of the other types. The Rosales Zoned Engraved sherds also cluster quite tightly, demonstrating coarser silt- to sand-sized grain profiles—there is also no overlap apparent with the Usulutan Red Rimmed samples. Finally, “imitation” Usulutan sherds present a scattered pattern of proportional distributions. What might be best described as “orphan samples”—extreme occurrences of very silty and very matrix-rich grain-size profiles that overlap with, respectively, both Rosales and Usulutan Red Rimmed types—bookend a small cluster of roughly equal proportions of matrix and silt inclusions but with highly variable amounts of sand-sized inclusions. That said, the “imitation” Usulutan samples seem to be more closely related to Rosales samples, in terms of grain size, than the Usulutan Red Rimmed examples.

Quantitative Point Counting: Analysis

As stated above, the purpose of undertaking a point counting analysis is to help distinguish between unique “paste recipes” (also presumably discriminating between local and nonlocal pastes), as well as create feasible research questions and provide and exploratory framework for subsequent petrological composition analysis. Results of the present point counting procedure managed all of these objectives. We have demonstrated that discernable differences exist between each of the types—especially between the two Usulutan types—with regard to grain size, although some type of grain-size related relationship seems to exist between Rosales Zoned Engraved samples and most of the “imitation” Usulutan (as initial macroscopic analyses suggested based on visual similarities in colour and inclusions). In conjunction with our initial queries of the samples outlined above, there were several research questions born out of this quantitative analysis and they include:

1. The relatively tight clustering of Usulutan Red Rimmed and Rosales Zoned Engraved types may be suggestive of standardization in production of these types. Does the compositional analysis support or refute this?

2. Are the differences in grain-size proportions witnessed between the Usulutan types the result of different petrological compositional profiles, or are they merely the result of different manufacturing “recipes” utilized with similar clays?

3. Similarly, is the apparent grain-size relationship between several of the Rosales Zoned Engraved and “imitation” Usulutan samples compositionally supported, or do they simply share coincidental grain-size trends?

4. Finally, can the petrological composition evidence inform us about the manufacturing origin of any of these types—were any *actually* imports to the site?

Qualitative Petrological Composition: Results

Summary results of the petrological composition profiles for each ceramic type are outlined below[2]. We have also provided an informal key (an ongoing project that may still contain minor errors or inconsistencies) to help the reader better understand the volcanic geological parent-rock environments from which the various clays and inclusions are derived (see Appendix 1). Appendix 2 contains complete petrological descriptions of the individual sherds sampled from La Arenera.

<u>Usulutan Red Rimmed</u>

Preliminary petrological analyses of samples associated with Usulutan Red Rimmed (initially believed to be an import to the site) ceramics present a fairly consistent "recipe", with all examples demonstrating a relatively fine, iron-rich clay matrix dominated by quartz, opaques (likely magnetite and/or hematite), devitrified materials, and biotite mica. Larger inclusions (and potential types of temper) are predominantly quartz, followed by lesser amounts of opaque and ferrous inclusions, vitric tuff with quartz phenocrysts, and iron-stained, altered volcanic glass and biotite mica.

All of these suggest parent igneous environments of a <u>**felsic nature**</u> and, in this highly volcanic region, were *likely created by dacitic volcanic activity and lava flows*. While there is a tendency to see dark red to brown iron staining occur in more iron-rich mafic and intermediate (a mix of felsic and mafic) environments, minor felsic accessory minerals such as magnetite—which is well represented here—alter with heat and water loss to hematite (which, in turn, alters to ochre) and provide a possible explanation for the iron-staining and vitric alteration we see in these samples. The occurrence of rare shell inclusions in samples AR1 and AR3 is of interest and may aid in assessing provenience where reasonable comparative material is available.

<u>"Imitation" Usulutan</u>

Analyses of the "imitation" Usulutan type present a group of ceramics with a completely different petrological composition than the Usulutan Red Rimmed type discussed above.

[2] Time restrictions on the preparation of this paper preclude proper reporting of inclusion proportions, which are generally presented in terms of overall percentages of each inclusion type.

Unlike the Red Rimmed type, these samples demonstrate some inconsistency in the "recipe" used to create the vessels—while the petrological composition is similar, the relative amounts and types of mineralogical and lithic inclusions can vary quite dramatically, in some cases, between samples. Clay matrices range from fine grained with well-sorted, silt-sized inclusions (AR7, AR8) to congested with moderately-sorted, silt- to sand-sized inclusions (AR6, AR9, AR10).

Generally speaking, these fabrics are very colourful under cross polar light due to the large amount of mafic rock-forming minerals present. These minerals are packed, in most examples, into the matrix with numerous varieties of clastic and igneous lithic inclusions. The numerous large inclusions present in most of the samples often make it difficult to assess the clay matrix itself. Dominant lithic materials include weathered and iron-stained volcanic tuff, scoria, plagioclase-phyric andesite, and pyroxene-phyric basalt. Mineral inclusions, in general decreasing order of abundance, include plagioclase feldspar (the dominant mineral present), orthopyroxene, clinopyroxene, opaques (magnetite and hematite), olivine, and hornblende. AR7 is the only example with rare instances of quartz. These petrological characteristics suggest parent igneous environments of a more **<u>mafic nature</u>** and, in this highly volcanic region, were *likely created by basaltic to andesitic volcanic activity and lava flows*.

<u>Rosales Zoned Engraved</u>

The Rosales samples present, once again, a completely different petrological composition than either of the Usulutan types. Within this sample group there appears to be significant variation in the "recipes" used to make this type, as well as minor variation in the petrological composition itself. All of the Rosales samples contain significant amounts of volcanic clastic and flow materials, which serves to group them together (to some extent) and simultaneously differentiate them from the Usulutan types.

AR12, AR14, and AR15 present an iron-rich clay matrix full of "ugly and chunky" heavily stained and/or decomposing/altering lithic and mineral inclusions. All are dominated by large lithic inclusions, especially iron-stained "foamy" pumice, scoria, altered basalt. Mineral inclusions shared by these three samples include dominant plagioclase feldspar, followed by decreasing and far less frequent amounts of clinopyroxene, orthopyroxene, opaque inclusions, and biotite. Where they differ is in rarely occurring minor/accessory minerals and lithics such as altered quartz (AR14 and AR15), olivine (AR14), hornblende (AR15), gabbro-like agglomerations (AR15), and vitric tuff (AR15). AR13 and AR16 present glassy matrices, however they are different in every other respect. AR13 is an ash-tempered fabric with iron-stained, altered tuff and tiny fragments of feldspar, quartz, and biotite. AR16 contains a wide variety of pumice types, opaque inclusions, and very few minerals—rare occurrences include tiny fragments of feldspar, quartz, and biotite. These petrological characteristics suggest parent igneous environments of a more **intermediate nature** and, in this highly volcanic region, were *likely created by dacitic to basaltic volcanic activity (including clastic/explosive activity) and lava flows*.

Qualitative Petrological Composition: Analysis

Results of the petrological composition analysis indicate significantly different paste compositions for each type examined which, in turn, suggests the likelihood of different geological sources and geographical manufacturing areas. The compositional analysis also allows us to address, to varying degrees, the research questions we derived from the quantitative point counting analysis. Here we discuss the first three of those questions in turn, elaborating in the final discussion the question as to whether or not any of the types were potentially locally produced or imported into the site.

1. The relatively tight clustering of Usulutan Red Rimmed and Rosales Zoned Engraved types may be suggestive of standardization in production of these types. Does the compositional analysis support or refute this?

The Usulutan Red Rimmed ware demonstrated a general consistency in both grain size and petrological composition. This suggests that, for this particular set of samples, the vessels were *likely* produced in a similar geological and geographical location by potters (single, multiple, or communities?) with a specific understanding of how the pastes are to be prepared, as well as how the vessels should be built and subsequently decorated. Referring back to Table 1, we note that all but one of these samples were of a composite silhouette form. Future research may focus on whether the consistency in paste recipe—for Usulutan

Red Rimmed vessels at La Arenera—extends across different vessel forms (e.g., dishes or shallow bowls) in the assemblage. This would lend greater support to the argument for standardization in production of this particular ware.

Like the Usulutan Red Rimmed samples, Rosales Zoned Engraved wares demonstrated relative consistency in grain sizes. However, the same degree of consistency was not witnessed in the petrological composition of these samples. They do not all appear to be made by related potting groups and are *likely* from more than one production place/site/area. However, having said that, all of the samples belong to the same general geological environment. Although there appears to be significant variation in the paste "recipes" used to make this type, significant similarity in the finished vessels (the actual sherds themselves) suggests a standardized knowledge of how to create these vessels as a final product.

2. Are the differences in grain-size proportions witnessed between the Usulutan types the result of different petrological compositional profiles, or are they merely the result of different manufacturing "recipes" utilized with similar clays?

The differences in grain-sized proportions are definitively *not* merely the result of different manufacturing "recipes" utilized with similar pastes. The clays and inclusions encountered in each of these types are completely distinct, both in terms of grain size and petrological composition. As we anticipated at the outset, these two types of Usulutan wares are completely unrelated in every aspect other than decorative style.

3. Similarly, is the apparent grain-size relationship between several of the Rosales Zoned Engraved and "imitation" Usulutan samples compositionally supported, or do they simply share coincidental grain-size trends?

The proximity of grain-sized proportions witnessed for several samples (see Figure 4) is not an artifact of petrological composition and/or "recipe" relationships between Rosales Zoned Engraved and the "imitation" Usulutan types. They demonstrate completely different profiles in both respects and similar grain size appears to be merely coincidental. Lack of intra-sample consistency for the "imitation" Usulutan sherds, although overlapping to some degree with both of the other types, seem to provide us, most significantly, with an idea of the potential range of grain-size compositions we can expect to encounter in paste "recipes" amongst these types.

Initial macroscopic observations undertaken in the samples selection suggested similarities that were not apparent during the quantitative or qualitative examination. In fact, results of the compositional analyses have demonstrated an almost complete lack of relationship between the three types—Usulutan Red Rimmed, "imitation" Usulutan, and Rosales Zoned Engraved. Following the petrological analysis, it was apparent that the "imitation" Usulutan and Rosales Zoned Engraved types were not from the same location of production, and it was uncertain whether or not the Usulutan Red Rimmed samples were "real," imported ceramics from El Salvador—the supposed Usulutan "heartland." Through subsequent research, however, we have begun to make strides toward a better understanding of provenience and, perhaps, more complex sociocultural phenomenon. In the final discussion we turn to examine these aspects of provenience with the goal of shedding some new light on the Tempisque period ceramic economy at La Arenera.

DISCUSSION

The fourth research question outlined in our compositional analysis—also one of the main questions that drove the original sample selection—was whether or not the petrological composition evidence could inform us about the manufacturing origin of any of these types. We wanted to know if we could discern which types may have been the result of local production and/or which were imports to the site. In order to begin examining aspects of provenience it is first imperative to grasp a better understanding of the geological areas from which these ceramics were produced. Once this has been realized we move into the final portion of our discussion which attempts to couch the La Arenera samples, specifically the Usulutan wares, into a broader interregional framework of Izalco-style Usulutan ceramic manufacture, exchange and emulation.

Volcanism and Provenience

Highly volcanic regions such as Pacific Nicaragua can often present a homogeneous volcanic geological landscape that can impart a general "sameness" to the chemical composition of basic clay sources. However, inclusions added to these clays (especially pyroclastic materials) can help tease out and create distinct geological profiles, or fingerprints, that allow us to distinguish between geographic areas or regions of origin for these materials (Bishop et al. 1992:136–138). Ron Bishop and Fred Lange, working with various other colleagues, have laid the groundwork for and demonstrated the ability of both chemical and petrological composition analyses to provide a more thorough understanding of ceramic provenience and distribution in Pacific Nicaragua (Bishop et al. 1988, 1992). Unfortunately, their massive Greater Nicoya Ceramic Project did not include any reference material for Usulutan wares, and little is reported on the ceramic paste composition of Managua area ceramics. As a result, we were required to begin the creation of our own profiles based on current knowledge of volcanism[3] and geology in Pacific Nicaragua, and guided by the earlier work of Bishop and Lange.

That La Arenera is located on the slope of a series of volcanic fissure vents (the Nejapa-Miraflores Lineament) and was inundated in the past by periods of explosive volcanic activity is substantial and informative, especially with regard to questions of local ceramic production evidence. While we are not currently certain which volcanic eruption buried the site, there are two reasonable possibilities.

The first, and most obvious, is the Nejapa fissure vent itself. Traditional tephrochronology (dated layers of tephra deposition) states that this fissure exploded violently some time between 1050 B.C. and 50 B.C. (550 B.C. +/– 500 yrs). The existence of Izalco-style Usulutan wares (Demarest and Sharer 1982:819), however, would push the date of this eruption—if it is the actual eruption that buried La Arenera—to some time after 200–100 B.C. The composition of this (as well as previous and subsequent) eruption was *tholeiitic basaltic flow and clastic materials* (Global Volcanism Program 2010; Rausch and Schmincke 2010).

The second alternative possibility for the inundation of La Arenera is from the Apoyeque volcano, which is part of the Apoyeque Volcanic Complex that constitutes the Chiltepe Peninsula and extends (from the western side) into the south-central portion of Lake Managua. The last known and highly explosive *daisitic* eruption of this volcano—

[3] As well as individual volcanism studies, a major resource consulted has been the Smithsonian Institution's "Global Volcanism Program," an invaluable source of information including, especially, records of volcano composition, flow types, and individual volcano eruptive histories over the past 10,000 years.

one of the largest pyroclastic explosions ever recorded[4] (Global Volcanism Program 2010)—occurred at roughly 50 B.C. +/– 100 years. While it is possible that the Apoyeque eruption inundated the site of La Arenera, it may be more reasonable to hypothesize that the site was victim of both this and the Nejapa eruption sometime after 150 B.C., given the site's proximity to both volcanoes. The severe disruption that would have resulted from this relative 'onslaught' of volcanic activity in the area may also explain why there is no significant evidence of reoccupation before the Late Tempisque-Early Bagaces periods (approximately A.D. 1–500).

Regardless of which volcano (or even a combination of the two) inundated La Arenera, it seems apparent that the volcanic parent rock environment of the site location prior to this catastrophic activity had a largely *basaltic* character (and this is true of most of the volcanoes around the Lake Managua area). Thus, based on the compositional analysis, the sample type *most likely* produced locally in the site area would have been the "imitation" Usulutan—as we believed them to be at sample selection. The mafic, mineral-rich and iron-stained nature of the inclusions in the "imitation" Usulutan wares associates these ceramics with this type of geological environment. While we cannot say with certainty that the ceramics were produced at La Arenera until we have sufficient comparative data, the hypothesis for future study is that they most likely were from this general area[5]. This line of thinking may also be supported by the seemingly chaotic variety of paste "recipes" and the wide variety of vessel forms (see Table 1) witnessed in these samples. It may be reasonable to infer that these wares were most abundantly accessible from a wider variety of local potters—who may have been experimenting, based on an overall lack of standardization, with new forms and a decorative technology introduced from the north at this time—than we might see from imported wares derived from a circumscribed number of sites or potting groups.

Following this line of volcanic and geological argument we conclude, then, that both the Usulutan Red Rimmed and Rosales Zoned Engraved types were not produced locally as their compositional profiles do not seem to match the general local environment. If this is the case, where are these types potentially coming from?

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[4] Ranking just behind the 5th century Ilopango eruption that buried the site of Cerén in El Salvador.
[5] Other possible comparative geological locales include the León area and the Gulf of Fonseca area.

Rosales Zoned Engraved is a ubiquitous type found throughout Greater Nicoya during the Tempisque period. At sample selection, it was assumed that this type would most likely represent a locally-produced ceramic product. However, the compositional analysis suggests that they are not locally produced but, rather, imported into the site through whatever means (trade, exchange, gifting, etc.). The *intermediate* nature of the inclusions in these wares intimates production in parent geological environment related to *dacitic to andesitic volcanoes with episodic clastic/explosive activity*. The iron-rich stained matrix coupled with heavily stained and altered minerals, as well as glassy lithic (especially pumice) inclusions in these samples are highly reminiscent of monochrome wares—Sacasa Striated and Rivas Red—from the site of Tepetate, Granada (Dennett 2009). They also seem related, in terms of general petrological composition, to monochromes from the site of Santa Isabel, Rivas (Figure 5) (Dennett et al. 2008), but are missing the important and dominant andesite component that defines ceramic pastes from that site (although the Rosales AR15 sample would fit comfortably with ceramics produced at Santa Isabel).

Support for this line of argument comes from Bishop et al. (1988), who found that—from their extremely limited sample—Rosales Zoned Engraved ceramics seem to derive, in terms of chemical composition, from the Rivas area. Bishop et al. (1992) also suggest that the high iron content witnessed in later period Papagayo polychromes is characteristic of the Isthmus of Rivas and we assume that this occurrence can likely be confidently extended slightly deeper into the past. While we are not absolutely certain that these Rosales samples derive from the Isthmus of Rivas (between Granada and Rivas), we hypothesize that further compositional analyses will likely demonstrate that they are.

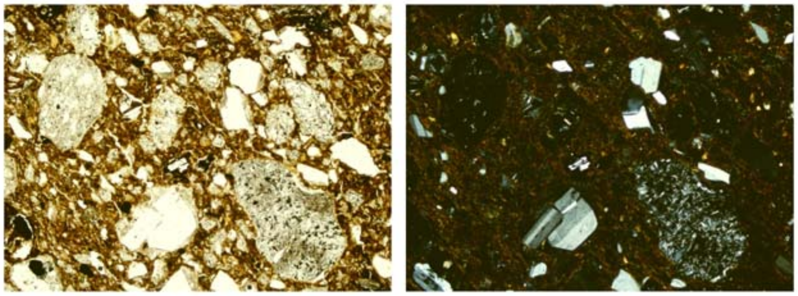

Figure 5. Rivas Red paste from the site of Santa Isabel, Department of Rivas, Nicaragua. Photomicrograph taken in 5x PPL (left) and 5x XPL (right).

The Usulutan Red Rimmed type, with a composition type quite different than the other two already discussed, is likely not locally manufactured but rather, like Rosales, represents an import to the site. Given the *felsic* nature of this paste and its inclusions, it seems to represent parent geological materials of *dacitic volcanic activity* characterized by a matrix dominated by quartz and glassy, altered lithics. We are hesitant to assign a potential production location simply because we have no comparative base to work from. Potential provenience areas—established volcanoes with dacitic flow and pyroclastic activity—are few and far between. Some preliminary considerations might include Ilopango, San Salvador, El Salvador; San Cristóbal, Chinandega, Nicaragua; and Momotombo, León, Nicaragua. There are also several volcanoes in highland Costa Rica that might "fit the bill," but we feel they are an inadequate direction for investigation at present. Given the wide-ranging distribution of these potential provenience locations, it becomes difficult to pinpoint any particular place without more research. However, an overall lack of "hard-fired" ceramics in Pacific Nicaragua—like that we see with the Usulutan Red Rimmed samples—also presents a potential problem and raises questions, although not so complex as to rule out a potential Nicaraguan provenience.

So the question then remains, was the Usulutan Red Rimmed type "real," meaning that it was imported from El Salvador (as originally hypothesized) or is there some other possible explanation? We turn now to take a more serious look at Izalco-style Usulutan and how the Usulutan Red Rimmed samples from La Arenera articulate with current knowledge regarding the production, exchange and emulation of Izalco-style negative resist decorative techniques along the southeast Mesoamerican periphery.

Production, Exchange, Emulation, and Interpretation of Izalco-style Usulutan

One major obstacle for researchers working outside of the Usulutan "heartland" of Preclassic period El Salvador has traditionally been the deeply entrenched and overly simplistic idea that hard-fired, negative resist decorated wares originate from El Salvador and were traded or exchanged outward from their point of production. Beginning in the early 1980s, a general consensus was achieved among archaeologists working in El Salvador that "Usulutan" was simply a decorative (negative resist technique) mode rather than a chaotic series of varieties to be subsumed under a single type, but that the origin of this decorative mode was (perhaps as early as 1100 B.C.) western El Salvador. The developmental decorative sequence ranged from “early, relatively crude, simple line-and-blob resist variants...to hard-fired, multiple-line resist Usulutan” (Demarest and Sharer 1982:813). This final stage of development is represented in the Izalco-style wares like the Red Rimmed samples from La Arenera.

Production of Usulutan (especially variants of the later Izalco style) across time, however, was not limited to western El Salvador. By roughly 200 B.C.–A.D. 50, the hard-fired Izalco-style Usulutan was being both (sparingly) imported into and produced across the Mesoamerican southeast periphery including the sites of Chalchuapa, Santa Leticia, and Quelepa in El Salvador, as well as several sites in the Copan[6], La Entrada, Naco Valley, Ulua Valley, Santa Barbara, and Comayagua Valley regions of Honduras—where local typologies include names such as Muerdalo Orange and Bolo Orange (Cagnato 2008:52; Demarest and Sharer 1982; Goralski 2008:43–60, 70, Table 1). The existence of Izalco-style Usulutan throughout areas of El Salvador and Honduras led to the hypothesis—initially developed by E. Wyllys Andrews V—of a Late Preclassic period (post 300 B.C.) interaction sphere, based on production and distribution, called the “Uapala sphere” (Figure 6) (Cagnato 2008; Goralski 2008:88–90). This sphere is represented by ceramics, sites, and likely languages (Lenca) east of the Rio Lempa, in El Salvador and Honduras (the traditional southeast periphery), and is differentiated from the earlier Middle Preclassic “Provedencia and Miraflores spheres” of Maya-speaking Mesoamerica proper (western El Salvador and southwest Guatemala—the Usulutan “heartland”) (Cagnato 2008:54; Goralski 2008:91).

Goralski (2008:71) states that Usulutan types throughout Honduras are known strictly from elite contexts, which has traditionally been interpreted as evidence for the importation of Usulutan into the country (as a status or prestige good) rather than local production/emulation. However, we now know that not only was most of the Usulutan produced locally but also that many of the imported Usulutan wares were produced at other sites within Honduras—with only trace amounts of El Salvadorian-produced wares

[6] Cagnato (2008) notes that the development of locally-produced Izalco-style Usulutan in the Copan Valley is co-occurring with shoe-shaped, zoned bichrome jars—a point which may of particular interest to those working in Pacific Nicaragua in the later Late Bagaces and Sapoá periods (A.D. 500–1250) when shoe-shaped pots become ubiquitous and co-occur with supposed imports of Ulua polychromes.

(Cognato 2008; Goralski 2008:255). For example, at the site of El Guayabal in the Paraíso Valley of Honduras, researchers have discovered locally-produced Izalco-style Usulutan *and* imports from the Copan Valley and other places[7] (Cagnato 2008:68).

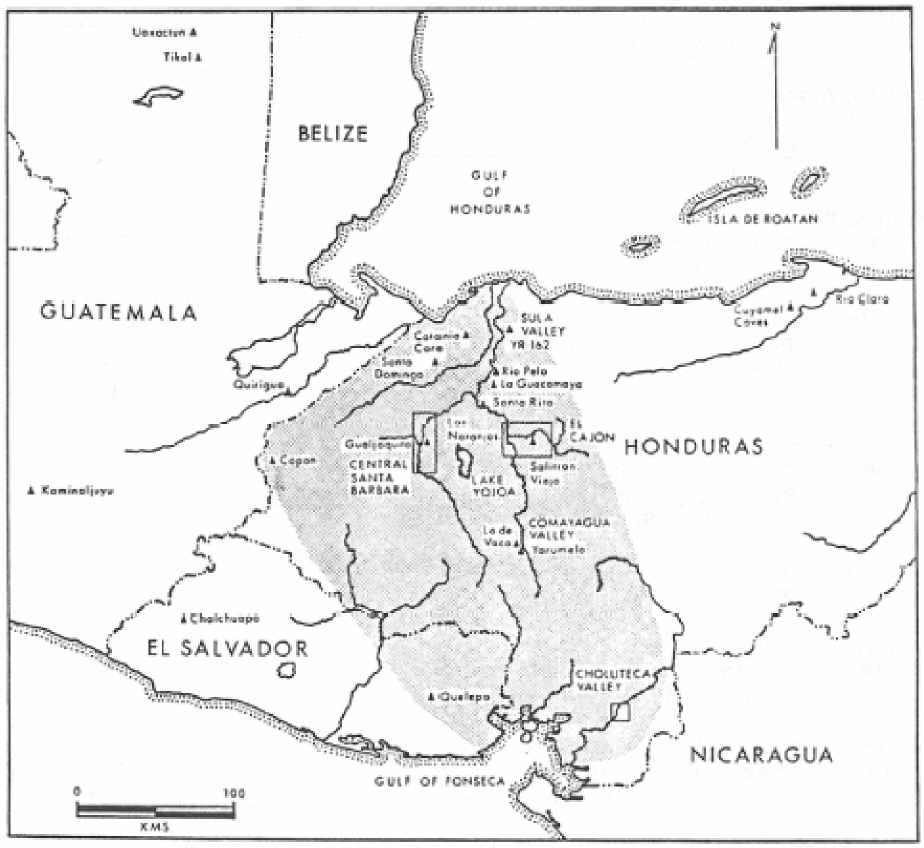

Figure 6. Map of the Uapala Ceramic Sphere Boundaries (after Robinson 1988, in Goralski 2008:1992)

This new understanding of the Uapala-Usulutan sphere has also resulted in new interpretations. Cagnato (2008:93), for example, suggests that elite groups at El Guayabal might not have had the ability or necessity to import "real" Izalco-style Usulutan from El Salvador, instead making their own versions for an elite display of prestige goods. Emulation, she suggests, demonstrates knowledge of these fine wares and may reflect an elite desire to exhibit long-distance sociopolitical connections or to "fit in" to a broader regional trend. Goralski (2008:278) similarly suggests that the development of the Uapala-

[7] Again, of interest is the fact that many of the "imported" sherds illustrated by Cagnato (2008, see fig. 4.6, for example) appear, macroscopically, quite similar to Vallejo polychrome from Sapoá period (A.D. 800–1250) Pacific Nicaragua, a type whose production provenience is currently in question.

Usulutan sphere is the result of both importation and emulation. The exchange of Usulutan within the sphere, however, may provide more intimate clues about the role of Usulutan as an elite good. Goralski (2008:284) suggests, based on production and distribution patterns, that Uapala-Usulutan was likely used as “daily serving vessels for elites to reinforce status differences, as a special service ware used in ritual feasts with other elites to force or renegotiate status differences, and as gifts given by elites to forge alliances and incur debts.”

Given the recent exploration and interpretative developments of Late Preclassic Usulutan ceramics, how does this information helps us garner a better understanding of Usulutan wares at La Arenera? Can we articulate the presence of Usulutan wares in Pacific Nicaragua with the broader Uapala-Usulutan sphere operating to the north? While the results of the current project are strictly preliminary, we believe we can begin to posit potential interpretations, in the hope that they will drive further investigation and elaboration in the near future.

Interpreting Usulutan Ceramics at La Arenera

In this paper we have demonstrated that at least one type, the “imitation” Usulutan from La Arenera, was likely locally produced based on geological and volcanic data from the area. We believe, again based on petrological composition, that the Red Rimmed Usulutan may have been produced in Pacific Nicaragua as well. Recent work by Craig Goralski (2011 personal communication) suggests that our interpretations are heading in the right direction, if not correct. In his compositional analysis of ceramics from throughout Honduras, and including samples from El Salvador, he found that conducting petrological analysis of the sherds was futile. The reasoning being that, in all cases, the paste was so fine and lacking any type of diagnostic inclusions that microscopic variation and composition was almost impossible to detect—the result forcing a compositional study almost completely based on chemical analysis (INAA). This was certainly not the case for the La Arenera samples (with ample diagnostic inclusions) which, based on Goralski’s work, suggest that none of the sherds derived from a northern production source and were, most likely, produced within Pacific Nicaragua.

Given the paucity of archaeological investigation at Tempisque period (Late Preclassic) sites in Nicaragua, it is currently impossible to know whether or not Usulutan decorated ceramics are limited to elite contexts, as is apparent for sites in Uapala ceramic sphere. However, the existence of two discrete paste types may favour an interpretation similar to that discussed by Goralski (2008:284). The co-occurrence of Nicaraguan-produced Izalco-style Usulutan wares and obsidian artifacts likely derived from Honduran sources implies a direct knowledge of the socioeconomic (at least, if not sociopolitical as well) framework operating to the north of La Arenera. It may be that leaders (chiefs?) were participating in a Pacific Nicaraguan version, or extension, of the Uapala-Usulutan interaction sphere, where locally-produced forms of this prestige good were somehow gifted or exchanged between leaders from different sites or political-economic zones (allied territories) in a social setting designed to foster new, or maintain existing, alliances and/or affiliations.

Supporting this hypothesis is the Rosales Zoned Engraved sample at La Arenera which, by all appearances, seems to be coming from the Granada or Rivas areas of the Isthmus of Rivas. Long viewed as a status or ritual ware, Rosales may have been another form of "elite" or leader exchange material. Healy (1980:239–241) also notes the occurrence of Usulutan Resist wares in the Rivas region. In fact he also forwards, in his paste descriptions, two discrete paste types—one a poor-quality imitation and the other a more "authentic"-looking paste. The dominant paste inclusions he notes are of feldspar and quartz, are not typically dominate compositional categories for the area but seem closer to those Red Rimmed types from La Arenera. It would be interesting to see if petrographic analyses could, in the future, define a relationship with the La Arenera samples.

Obviously there is much more work to be done and we realize that these preliminary analyses are merely that: preliminary. However, we feel that this project represents a good starting point—including a series of testable hypotheses—for exciting and informative future research.

CONCLUSIONS

In this paper we have introduced the site of La Arenera, provided preliminary results of the first compositional analysis conducted on the site's ceramic assemblage, and attempted to geologically contextualize our findings. The result has been a more detailed understanding of the provenience of both Usulutan-type and Rosales Zoned Engraved ceramic types. We found that Rosales ceramics are likely being produced and imported into the site from somewhere in the Rivas-Granada area of the Isthmus of Rivas. Further we found that there are two distinct paste types for the Usulutan-style ceramics from the site, both of which appear likely to have likely been produced within Pacific Nicaragua. We are certainly not the first to suggest that Usulutan-style ceramics were produced in Pacific Nicaragua (see Healy 1988; Lange 1992). However, this is the first time (as far as we know) that this type of detailed petrological compositional provenience study has been conducted at the site level. Finally, we have attempted to articulate the preliminary results of the La Arenera study with the broader Uapala-Usulutan ceramic sphere of the Mesoamerican southeast periphery, suggesting that Izalco-style Usulutan wares may have served as prestige goods utilized locally for status differentiation and regionally as a tool for forming or maintaining sociopolitical and socioeconomic alliances and/or affiliations.

Comparative petrographic information from other regions—especially Honduras, El Salvador, and northwest Costa Rica—would be useful in supporting these provenience interpretations. We are hopeful that the results of ongoing INAA and XRD analyses will help clarify the compositional relatedness both within and between types from La Arenera, and with other regions for which compositional databases currently exist.

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Appendix 1

Volcano and Lava Flow Types including brief Descriptions of their Chemical Composition and Associated Rock Types and Rock-Forming Minerals.

Volcano Type	**Lava Flow Type**	**Chemical Composition & Description**	**Associated Igneous & Volcanic Rock**	**Associated Rock-Forming Minerals**
Basaltic	Mafic	- High Iron and Magnesium Content -Low Silica and Aluminum Content	Dark Coloured Groundmass -Basalt (often with phenocrysts of plagioclase and olivine) -Gabbro (Igneous. It usually contains pyroxene [mainly clino], plagioclase, amphibole, and olivine) -Basalt Tuff -Scoria (am almost frothy basalt)	-Plagioclase Feldspar (major) -Olivine (major) -Clinopyroxene *Accessory Minerals*: -Biotite Mica, Hornblende, and Orthopyroxene (minor)
Dacitic and/or Rhyolitic	Felsic	- High Silica, Aluminum, Potassium, Calcium, and Sodium Content -Low Iron and Magnesium Content	Light Coloured Groundmass (generally crystalline to glassy) -Dacite (sodic plagioclase and quartz -phyric, often with less alkali feldspar) -Rhyolite (quartz and alkali feldspar-phyric) -Rhyolitic Tuff -Pumice (from gassy lava) -Ash (majority of pyroclastic ash is Felsic) -Ignimbrite (pyroclastic flow) -Also includes Granite (Igneous) and Obsidian	-Quartz (major) -Alkali Feldspar (major) -Muscovite Mica -Sodic Plagioclase Feldspar *Accessory (and phenocryst) Minerals*: -Orthopyroxene, Hornblende, and Biotite Mica. Magnetite(?)
Andesitic	Intermediate	-Intermediate between Mafic and Felsic, Generally with Higher Iron and Magnesium Content. -Tendency to Form Phenocrysts	Tendency Toward Darker, Porphyritic Groundmass -Andesite (type differentiated by the dominant phenocryst mineral, generally plagioclase + one or more mafic minerals such as orthopyroxene [high], hornblende and olivine [moderate], and biotite [trace]) -Andesitic Tuff (dark, often decomposed glassy matrix) -Trachyte -Diorite (Igneous and associated with Gabbro, it generally contains plagioclase, biotite, hornblende, and/or pyroxene)	Emphasis on Mafic Rock-Forming Minerals -Plagioclase Feldspar -Orthopyroxene -Hornblende (moderate) *Accessory Minerals:* -Magnetite, Olivine, and Biotite Mica

Appendix 2

Preliminary Individual Thin Section Descriptions

AR1 – Usulutan Red Rimmed

General –

This sample presents a well-sorted, iron-rich clay matrix dominated by silt-sized grains. Many wide voids in the fabric appear to be a combination of both firing effects and the loss of mineral and/or lithic materials during thin section preparation. This sherd also shows a thick reduced core in cross section.

Lithic Inclusions –

The only lithic inclusions encountered in this thin section were infrequent iron-stained, decomposing and/or altered volcanic glass. The extreme erosion makes it difficult to say anything more about these.

Mineral Inclusions –

The matrix is dominated by tiny fragments of opaque, quartz, biotite, and devitrified (showing yellow to orange with no extinction under crossed polars) materials. Potential temper appears to be comprised of larger, evenly distributed, and predominantly subangular to subround quartz grains. These are accompanied by frequent, and equally large, opaque grains (likely magnetite), hematite, round ferrous inclusions (likely ochre) and, rarely, well-weathered biotite mica (pleochroism under plane polar light is yellow to orange). There is a single sand-to-gravel size angular calcite fragment.

Other Inclusions – Two instances of u-shaped shell fragments.

AR2 – Usulutan Red Rimmed

General –

Similar to AR1, with the exception of no obvious shell inclusions and the presence of additional lithic materials. This sample presents a well-sorted, iron-rich clay matrix dominated by silt-sized grains.

Lithic Inclusions –

Lithics encountered include infrequent iron-stained, decomposing and/or altered volcanic glass. The extreme erosion makes it difficult to say anything more about these. Also present were very large welded, porphyritic tuff materials containing (what appear to be) quartz phenocrysts and elongate feldspar microliths. Here the constituent minerals were difficult to identify because they were masked by an iron-stained glassy matrix. There were, however, additional examples of clear-glass vitric tuff with tiny quartz phenocrysts.

Mineral Inclusions –

The matrix is dominated by tiny fragments of opaque, quartz, biotite, and devitrified (showing yellow to orange with no extinction under crossed polars) materials. Potential temper appears to be comprised of larger, evenly distributed, and predominantly subangular to subround quartz grains. These are accompanied by frequent, and equally large, opaque grains (likely magnetite), hematite, round ferrous inclusions (likely ochre) and, rarely, well-weathered biotite mica (pleochroism under plane polar light is yellow to orange).

AR3 – Usulutan Red Rimmed

General –

Almost identical to AR1 – Usulutan Red Rimmed. This sample presents a well-sorted, iron-rich clay matrix dominated by silt-sized grains.

Lithic Inclusions –

The only lithic inclusions encountered in this thin section were infrequent iron-stained, decomposing and/or altered volcanic glass. The extreme erosion makes it difficult to say anything more about these.

Mineral Inclusions –

The matrix is dominated by tiny fragments of opaque, quartz, biotite, and devitrified (showing yellow to orange with no extinction under crossed polars) materials. Potential temper appears to be comprised of larger, evenly distributed, and predominantly subangular to subround quartz grains. These are accompanied by frequent, and equally large, opaque grains (likely magnetite), hematite, round ferrous inclusions (likely ochre) and, rarely, well-weathered biotite mica (pleochroism under plane polar light is yellow to orange).

Other Inclusions – One instance of a u-shaped shell fragment.

AR4 – Usulutan Red Rimmed
General –
Similar to the other Usulutan Red Rimmed samples (AR1, 2, 3, and 5), with the exception of a high feldspar component. This sample presents a well-sorted, iron-rich clay matrix dominated by silt-sized grains. This sample demonstrates a very large, carbon-rich reduced core.

Lithic Inclusions –
Lithics encountered include infrequent iron-stained and heavily weathered tuff-like inclusions. Other large glassy inclusions were apparent with heavily weathered, elongate feldspar phenocrysts coupled with fragments of biotite mica.

Mineral Inclusions –
The matrix is dominated by tiny fragments of opaque, quartz, biotite, and devitrified (showing yellow to orange with no extinction under crossed polars) materials. Potential temper appears to be comprised of larger, evenly distributed, and predominantly subangular to subround quartz grains. These are accompanied by frequent, and equally large, opaque grains (likely magnetite), hematite, round ferrous inclusions (likely ochre) and, rarely, well-weathered biotite mica (pleochroism under plane polar light is yellow to orange). Also evident are frequent and very large sand-sized feldspar grains.

AR5 – Usulutan Red Rimmed
General –
Similar to AR1, 2, and 3. This sample presents a well-sorted, iron-rich clay matrix dominated by silt-sized grains.

Lithic Inclusions –
Lithics encountered include infrequent iron-stained, decomposing and/or altered volcanic glass. The extreme erosion makes it difficult to say anything more about these. There were, however, additional examples of clear-glass vitric tuff with tiny quartz and/or orthoclase feldspar phenocrysts.

Mineral Inclusions –
The matrix is dominated by tiny fragments of opaque, quartz, biotite, and devitrified (showing yellow to orange with no extinction under crossed polars) materials. Potential temper appears to be comprised of larger, evenly distributed, and predominantly subangular to subround quartz grains. These are accompanied by frequent, and equally large, opaque grains (likely magnetite), hematite, round ferrous inclusions (likely ochre) and, rarely, well-weathered biotite mica (pleochroism under plane polar light is yellow to orange).

AR6 – Usulutan
General –
This sample presents a highly congested, moderately sorted clay matrix dominated by large (upper end silt and sand) sized lithic and mineral inclusions. This paste can perhaps best be described as a “chunky kaleidoscope of colour.” The matrix is, literally, overwhelmed by inclusions (temper?).

Lithic Inclusions –
Lithics encountered include a number of large (large silt to sand sized) volcanic clastic and igneous inclusions. No single type seems to dominate but, rather, there is a mix of: weathered and iron-stained, welded tuff; scoria (made up of devitrified materials, feldspar mircolites, and opaques in a glassy matrix); plagioclase-phyric andesite (meaning andesite where the dominant phenocrysts are plagioclase feldspar); pyroxene-phyric basalt (massive pyroxene phenocrysts). There is another lithic material that I am presently unable to identify—possibly chalk.

Mineral Inclusions –

Competing with the lithic material for presence in this clay matrix are predominantly large, sand-sized pieces of plagioclase feldspar and both ortho- and clino-pyroxene. Additional silt-sized and infrequent minerals encountered include amphibolite (likely hornblende) and olivine.

AR7 – Usulutan

General –

This sample presents a well-sorted, fine (smaller silt sized) grained clay matrix. The production of this thin section resulted in a sample ground so thin that it is difficult to discern much beyond some basic optical properties.

Lithic Inclusions –

There were no diagnostic lithic materials visible in the sample (although there are likely at least some there in the actual sherd).

Mineral Inclusions –

The matrix is completely dominated by a fairly homogenous mix of tiny fragments of feldspar (with the odd larger piece), what appears to be hematite, opaque inclusions (likely magnetite), pyroxene, and quartz—all in decreasing quantities.

AR8 – Usulutan

General –

This sample presents a fairly well-sorted clay matrix consisting of predominantly silt-sized inclusions.

Lithic Inclusions –

Lithic materials are poorly represented in the matrix with only rare occurrences of well-rounded scoria, basalt, tuff, and andesite.

Mineral Inclusions –

The matrix is spackled with tiny bits of mineral that demonstrate high (3^{rd} order interference colours) birefringence under crossed polars (muscovite or olivine?) that are likely native to the clay. The majority of silt-sized inclusions include plagioclase feldspar, olivine, and fragments of devitrified material. Less frequent larger, sand-sized entities are predominantly plagioclase feldspar, with slightly lesser amounts of orthopyroxene and infrequently occurring clinopyroxene.

AR9 – Usulutan

General –

Highly similar to AR6, this sample presents a highly congested, moderately sorted clay matrix dominated by large (upper end silt and sand) sized lithic and mineral inclusions. This paste can perhaps best be described as a "chunky kaleidoscope of colour." The matrix is, literally, overwhelmed by inclusions (temper?).

Lithic Inclusions –

Lithics encountered include a number of large (large silt to sand sized) volcanic clastic and igneous inclusions. No single type seems to dominate but, rather, there is a mix of: weathered and iron-stained, welded tuff; scoria (made up of devitrified materials, feldspar mircolites, and opaques in a glassy matrix); plagioclase-phyric andesite (meaning andesite where the dominant phenocrysts are plagioclase feldspar); pyroxene-phyric basalt (massive pyroxene phenocrysts).

Mineral Inclusions –

Competing with the lithic material for presence in this clay matrix are predominantly large, sand-sized pieces of plagioclase feldspar and both ortho- and clino-pyroxene. Additional silt-sized and infrequent minerals encountered include amphibolite (likely hornblende) and olivine.

AR10 – Usulutan

General –

Again similar to AR6 and AR9, this sample presents a highly congested, moderately sorted clay matrix dominated by large (upper end silt and sand) sized lithic and mineral inclusions. This paste can perhaps best be described as a "chunky kaleidoscope of colour." The matrix is, literally, overwhelmed by inclusions (temper?).

Lithic Inclusions –
Lithics encountered include a number of large (large silt to sand sized) volcanic clastic and igneous inclusions. No single type seems to dominate but, rather, there is a mix of: weathered and iron-stained, welded tuff; scoria (made up of devitrified materials, feldspar mircolites, and opaques in a glassy matrix); plagioclase-phyric andesite (meaning andesite where the dominant phenocrysts are plagioclase feldspar); pyroxene-phyric basalt (massive pyroxene phenocrysts).

Mineral Inclusions –
Competing with the lithic material for presence in this clay matrix are predominantly large, sand-sized pieces of plagioclase feldspar and both ortho- and clino-pyroxene. Additional silt-sized and infrequent minerals encountered include amphibolite (likely hornblende) and olivine.

AR11 – Usulutan
General –
This sample presents an iron-rich matrix with many voids (elongate fissures) and is dominated by large mineral and, less frequently, lithic inclusions.

Lithic Inclusions –
Lithic materials encountered include scoria, basalt, tuff, and a few instances of unidentified volcanic lithic fragments.

Mineral Inclusions –
Large sand-sized chunks of subangular and angular plagioclase feldspar dominate this matrix. Most of these inclusions have a lithic "rind" and probably represent dislodged or eroded andesite phenocrysts. Other large mineral inclusions are opaques and, infrequently, weathered and/or altering pyroxenes.

AR12 – Rosales Zoned Engraved
General –
This sample can best be described as having an iron-rich clay matrix dominated by "ugly and chunky", heavily altered and/or decomposed and iron-stained mineral and lithic inclusions.

Lithic Inclusions –
Lithic materials include iron-stained round and subround pumice fragments, scoria, and one other currently unidentifiable igneous rock type. The frothy pumice inclusions are characterized by their "puffy" appearance and well rounded glassy vesicles.

Mineral Inclusions –
This sample is dominated by large, sand-sized plagioclase and altered plagioclase feldspar inclusions. Also present are examples of large, well-rounded hematite and, notably less frequently, biotite mica, clinopyroxene, and orthopyroxene.

AR13 – Rosales Zoned Engraved
General –
Unique to the entire analysis of La Arenera thin sections, this sample presents an ash-tempered matrix with well sorted tiny mineral inclusions. The ash tempering is discernable by the diagnostic shards of curved and altered glass that once made up the glassy structure surrounding gas bubbles.

Lithic Inclusions –
The only lithic inclusions present in this sample are small fragments of iron-stained and devitrified volcanic materials, perhaps altered tuff (?).

Mineral Inclusions –

The matrix is dominated by small fragments of feldspar and quartz, with possible miniscule fragments of biotite mica (?).

AR14 – Rosales Zoned Engraved

General –

Quite similar to AR12, this sample can best be described as having an iron-rich clay matrix dominated by "ugly and chunky", weathered/altered/decomposed and heavily iron-stained mineral and lithic inclusions.

Lithic Inclusions –

Lithic materials include weathered and iron-stained round and subround pumice fragments, scoria, and small fragments of weathered basalt. The frothy pumice inclusions are characterized by their heavy iron-stained properties, "foamy" appearance, and well rounded glassy vesicles.

Mineral Inclusions **–**

This sample is dominated by large, sand-sized plagioclase and altered plagioclase feldspar inclusions, as well as silt to sand-sized altered quartz. Also present in significant amounts are examples of large, well-rounded hematite, clinopyroxene, orthopyroxene, olivine, and biotite mica.

AR15 – Rosales Zoned Engraved

General **–**

This sample demonstrates a moderately-sorted clay matrix with a very heterogeneous petrological composition and distribution of grain sizes ranging from sub-silt to gravel. Most inclusions are iron-stained.

Lithic Inclusions –

A variety of lithic materials dominate this sample. The matrix itself is spattered with many fine to miniscule (and thus difficult to identify) ferrous, glass, and rock inclusions. Sand-sized inclusions are generally well-rounded and heavily stained pumice fragments. The largest (perhaps best described as massive) inclusions are all iron-stained and include "foamy" pumice, altered and weathered andesite, vitric tuff (some look more ashy, while others look more pumice-like) with altered plagioclase phenocrysts, round ferrous inclusions (possibly decomposing hematite), scoria, welded tuff, and basalt. Rare instances of gabbro-like mafic agglomerations and some type of sedimentary rock (currently uncertain if this is chert, chalk, or limestone because it is so stained) are also present.

Mineral Inclusions –

Aside from the lithic inclusions mentioned above, the clay matrix is also full of tiny bits of difficult to identify mafic minerals. Otherwise, all mineral inclusions are in the sand to gravel sized range and include quartz, plagioclase feldspar, biotite, hornblende, and pyroxene.

AR16 – Rosales Zoned Engraved

General **–**

Unlike most of the other Rosales examples, this sample presents a clean and extremely glassy clay matrix with many tiny fragments of devitrified materials.

Lithic Inclusions –

Volcanic debris clearly dominates this sample with a variety of different pumice types including larger examples of clear "foamy" pumice, altered pumice with large orthoclase feldspar phenocrysts, smaller, silt-sized fragments of vesicular pumice, and rare instances of a clear glass with phenocrysts that likely represent fragments of altered pumice. Other lithic materials include modest amounts of welded tuff, rounded ferrous inclusions, and unidentified glassy lithic fragments with densely organized feldspar microliths (likely scoria).

Mineral Inclusions **–**

Mineral inclusions are far less frequent than their lithic counterparts. In fact, most of the larger silt to sand-sized mafic mineral inclusions appear to have a glassy rind, suggesting they were once lithic (likely pumice or tuff) phenocrysts. Plagioclase feldspar is the dominant mineral, although round ferrous and opaque inclusions, as well as orthoclase feldspar, appear in modest amounts. Also evident are rare examples of pyroxene and olivine.